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A STUDY OF THE INCIDENCE, NATURE, AND CAUSE OF SKI INJURIES AT MARMOT BASIN SKI RESORT, JASPER NATIONAL PARK, ALBERTA, CANADA

by

© MAURICE DONALD RICHARDS

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "A Study of the Incidence, Nature, and Cause of Ski Injuries at Marmot Basin Ski Resort, Jasper National Park, Alberta, Canada" submitted by Maurice Donald Richards in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

The purpose of this study was to investigate the incidence of injury at Marmot Basin Ski Resort and examine the nature and cause of recorded accidents so that effective and meaningful suggestions could be made which might aid in the reduction of injuries in the future.

An accident report form was specifically designed for the study. The form was comprised of twenty-three sections relating to individual body factors, skiing equipment factors, injury factors, and ski slope factors. The report form was designed to allow for computer analysis of all sections and factors. Computer analysis was completed on an I.B.M. 360/67 computer utilizing Fortran IV computer language.

One hundred and eighty-six casualties were treated at the resort during the 1968-69 skiing season.

Within the limitations of this study, the following conclusions have been made. The injury rate of skiers at Marmot Basin Ski Resort during the 1968-69 skiing season was 0.328 per cent which was less than the rate reported in the majority of injury surveys reviewed. The injury rate was noticeably higher during the first two months of the skiing season.

Two-thirds of all ligamentous injuries occurred to women. Three times more women than men were hurt on the beginner slopes. Younger skiers (twenty years and under) suffered three-fifths of the injuries.

Three-quarters of the skiing accidents occurred during the afternoon skiing period. As the ski day progressed more skiers of low skiing ability were injured on more advanced ski slopes.

One-fifth of all accidents were caused by buried rocks and stumps, moguls, and the condition of the loading areas of the ski lifts.

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One-half of the skiers injured were hurt because they were unable to handle snow or slope conditions.

Heel-toe release bindings were found to be most effective in reducing serious injuries. One-tenth of injured skiers were injured because of faulty equipment. One-quarter of the injured skiers were hurt using skis or ski poles of improper length.

One-fifth of all injured skiers were using rented or borrowed equipment. These skiers had a high release binding failure rate and an equally high incidence of serious injury.

Two-thirds of all lacerations were to the head. One-eighth of the skiers injured suffered multiple injuries.

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

Inherent in any physical activity is the element of risk. While the element is seldom a determining factor in an individual's participation in any physical activity, definite steps should be taken to effectively reduce the frequency and severity of injury in each pastime, game or sport.

In 1963, Kowalski (1) estimated that throughout the world each year one million persons were beginning to ski. In the United States in 1958 it has been estimated that there were approximately three and one-half million active skiers (2). Current Canadian estimates vary from two hundred and fifty thousand (3) to seven hundred thousand skiers (4). It is further estimated that on any given skiing day, from 0.2 to 1.3 per cent of the active skiers will be injured (5).

There is only one ski accident study currently being done in Canada. This study is being done by the Canadian Ski Patrol System (C.S.P.S.) largely in the eastern and central provinces of Canada. The C.S.P.S. study is not for publication and therefore serves only internal uses (6). There have been no studies completed to reflect the accident level of any Western Canadian ski resort in the last ten years (7).

Because of the increased emphasis upon physical fitness, increased leisure time, improved winter travel conditions, increased personal awareness of the value of recreational activities, rapid expansion of facilities for public skiing, and increased number of persons engaging in skiing, it seemed desirable to investigate fully the incidence, nature, and cause of

skiing injuries so information would be available to skiers on care and prevention of injuries through safety.

The Problem

The purpose of this study was to determine the incidence of injury at an expanding ski resort and examine the nature and cause of all recorded accidents so that effective and meaningful suggestions could be made and directed at reducing the incidence of injury in subsequent years.

The Need for the Study

At the time the study was undertaken, no current reports on ski injuries in Canadian Rocky Mountain ski areas were available to the public. Such a report was deemed desirable.

There was a need to ascertain if accidents at a particular resort could be equated to national reports or if, perhaps, the type of accident occurring tended to be peculiar to one ski area.

At the time the study was undertaken, the operators of the Marmot Basin ski resort had limited information on the causes and incidence of ski injuries in their area. Any information which would enable them to enhance their operation by lowering the number of ski accidents would be beneficial to them.

There was a need to develop a simple yet comprehensive accident report form from which valuable information relative to ski injuries could be derived. Within the limitations of the study, such a form was developed. The form was designed to permit computer analyses of information recorded on it.

Delimitations

In carrying out the study, a number of restrictions had to be placed

on the sample and the study. The delimitations were:

1. only the ski resort at Marmot Basin in Jasper National Park, Alberta, was considered.
2. the study was limited to one skiing season from November 23, 1968, to April 27, 1969.
3. the study was limited to the period of time between the opening and closing dates that the resort was operating for the general public.

Limitations

In addition to the delimitations stated above, certain limitations became evident as the study progressed. These included the following:

1. only those persons treated for first aid by the patrolling body prior to their removal from the resort were included in the results.
2. the accuracy of the answers given on the report form was not questioned and was, at all times, assumed to be correct.
3. while the accident report form appeared to be clearly stated, individuals completing it may have misinterpreted some areas and in doing so gave improper information.
4. there may be error in the process of collecting, interpreting, and summarizing the accumulated data.

Definition of Terms

Incidence. The rate of occurrence of ski injuries. This rate is expressed as so many accidents for each one thousand skiers on each ski day, or, as a projection to that level where the number of skiers is less than one thousand. The incidence can also be expressed as a percentage;

e.g., ten per one thousand ski-man days means ten accidents for each one thousand skiers each day, or an injury rate of one per cent per day.

Nature of Injury. The injury sustained in the ski accident; e.g. leg fracture, knee sprain, laceration.

Cause of Injury. An aetiological analysis of an injury. In most instances the cause or causes given reflect the opinions of the injured skiers.

Ski Patrolman. Any person, male or female, who had completed first aid and skiing requirements to be qualified to care for injured skiers or control the skiing public at the Marmot Basin ski resort. All patrolmen were members of the volunteer Canadian Ski Patrol System (C.S.P.S.), or professionals employed by Marmot Basin Ski Lifts Limited. Patrolmen had the responsibility of completing the accident report forms on treated victims.

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CHAPTER II

REVIEW OF THE LITERATURE

Incidence of Injury

The incidence of skiing injuries, expressed as a percentage or reflected as the number of skiers injured for each one thousand people skiing on any given day, has appeared in many reports and surveys of ski injuries. It is difficult to say whether the figure is most valuable as a national figure or as a figure associated with a specific ski area. For the most part the incidence has been reported as a figure reflecting injuries to skiers in total. Only the larger recent studies reflect the incidence of injury to age groups and skill groups. A chronological examination of the incidence of injuries as reported is now presented.

Morrison and Coughlin (1) estimated that there were approximately eight million skiers in the world in 1948. Based on their survey of accidents in the Berkshires of Western Massachusetts and Southern Vermont, they estimated that two skiers were injured per one thousand ski-man days.

Summarizing the reports of the National Ski Patrol System (N.S.P.S.) Rigos et al. (2) estimated that there were two and one-half million skiers in the United States in 1956-57 and, that on an average, five of every one thousand skiers on any given day were injured, or 0.5 per cent. The rate varied from 0.2 to 1.3 per cent depending upon the location and size of the resort. This figure is more than two and one-half times that stated by Morrison and Coughlin (1). Rigos et al. (2) noted that sixty per cent of all skiers were male.

An estimate closer to Morrison and Coughlin's was expressed by Erskine (3) who indicated that by 1958 the American ski population had approached three and one-half million and the accident rate was 2.7 per one

thousand skiers. It is somewhat likely that Erskine had based his estimate on a local study for Moritz (4) reported for the same year an accident rate approaching ten per one thousand. Erskine noted in his study that seventy per cent of all skiers were under the age of thirty. Hendryson ascertained the percentage of casualties occurring to certain age groups. His findings are summarized in Table I.

TABLE I

Who Gets Hurt

Age Group	Percentage Skiing	Percentage Injured
13 - 17	16	28
18 - 21	11	22
22 - 30	35	26
31 - 40	22	9
41 - 50	6	3

It should be pointed out that twenty-seven per cent of all skiers were twenty-one and under yet they accounted for fifty per cent of all injuries. Hendryson further noted that skiers who had skied five times or less accounted for twenty per cent of all accidents while they represented only ten per cent of the ski population. Skiers with more than five years' experience accounted for twenty-five per cent of all skiers yet suffered only twelve per cent of recorded accidents.

Arnott (6) indicated that the accident rate of six resorts in Western Washington and Western British Columbia averaged 2.64 per one thousand ski-man days in the 1957-58 skiing season. This figure compares with Erskine's

(3) estimate. Arnott noted that the British Columbia resorts on Grouse, Seymour, and Hollyburn Mountains had injury rates per one thousand skiers of 1.68, 2.01, and 1.60 respectively, while the Washington resorts of Snoqualmie Pass, Stevens Pass, and Mount Baker had rates of 2.96, 2.97, and 4.37 respectively. In an age group catergorization Arnott determined that the age group from thirteen to seventeen accounted for forty-two per cent of all accidents. The twenty-two to thirty age group accounted for twenty-one per cent of all accidents while the eighteen to twenty-one and seven to twelve age groups showed percentage rates of eighteen and ten respectively. Arnott explained that the figures were not truly representative of the age groups as estimates of the total ski population in each group were lacking. Of the total injured five women were injured for every six males. The percentage of novices and intermediate skiers sustaining injuries was equal while the expert group suffered only about half as many injuries as either of the other two groups.

Earle et al. (7) surveyed accidents at Bald Mountain in Sun Valley, Idaho, during the 1960-61 ski season and recorded an accident rate of 7.4 persons per one thousand ski-man days. The N.S.P.S. division operating in the same area noted an injury rate for the resort of only 1.8 persons per thousand. The authors rationalized that the patrol figures were far from complete. The difference represented the so-called "walking wounded." In a final analysis, Earle et al. felt that many other skiers by-passed the aid offered and that a better estimate of the incidence of injury was near one per cent.

One of the most complete studies on ski injuries has been compiled by Haddon et al. (8), who determined the incidence of injury for skiers in certain age groups and in certain turn groups. A further division of skiers by sex allowed for additional information.

Table II reflects the findings of Haddon et al. (8). Sixty-five per cent of all skiers were male and accounted for fifty-three per cent of recorded injuries, while women skiers represented thirty-five per cent of ski participants and suffered forty-seven per cent of injuries incurred. While the snow plow turn group accounted for only twenty-one per cent of those skiing, the group suffered fifty-five per cent of all injuries. Their injury rate was 1.6 per cent while the stem christie and parallel groups had rates of 0.4 and 0.3 per cent respectively. The injury rate for females was 0.8 per cent compared to only 0.5 per cent for males. The younger age groups had a significantly higher injury rate than the over thirty year old group. The authors noted the overall injury rate of the area surveyed was 0.6 per cent but agreed with Earle et al. (7) that the true rate was likely nearer one per cent. Haddon et al. (8) further indicated that only thirty-one per cent of women skiers and eighteen per cent of men skiers were married. The authors noted that prior injury was absent in ninety per cent of people sustaining injury.

It has been reported in the Lancet that the ski injury rates for Europe and North American were between 0.5 and 1.0 per cent per ski day in 1962 (9). This is somewhat less than the 1.6 per cent rate reported by Brocklehurst (10) in his European study of 1962-63. Brocklehurst noted that the unusually high rate recorded was due to the greater number of inexperienced skiers in the study group.

Kowalski (11) in citing an accident rate of 0.6 per cent in 1963 indicated that an additional one million skiers were joining already active skiers each year.

McAlister et al. (12) found that, on an average, 7.3 skiers per one thousand ski-man days were being injured at a ski resort near Anchorage, Alaska, in 1964. This figure compares with the 0.7 per cent rate quoted

TABLE II

Injury Rates of Male and Female Skiers Related

to Turn Group and Age

Turn Group and Age	Male: Percent of All Males	Male: Injury Rate Per 1000 Ski-Man Days	Female: Percent of All Females	Female: Injury Rate Per 1000 Ski-Man Days	Both Sexes: Percent of All	Both Sexes: Injury Rate Per 1000 Ski-Man Days
Snow Plow	13		36		21	
Under 20 years		24		16		19
20-29 years		24		19		21
30 and over		9		6		7
Stem Christie	29		36		32	
Under 20 years		6		4		5
20-29 years		5		9		6
30 and over		2		3		2
Parallel and Wedeln	58		28		47	
Under 20 years		3		4		3
20-29 years		2		6		3
30 and over		2		5		3

by Harwood (13) in 1966.

Ball (14) indicated in 1960 that 700,000 people skied in Canada and that nearly 33,000 of them would be treated for accidents. This represented 4.7 per cent of all skiers in Canada, yet the figure was much lower than the estimated ten per cent of the three and one-half million skiers of the United States, which Ball stated the N.S.P.S. had estimated would be injured. Ball presented figures similar to Rigos et al. (2) indicating that sixty per cent of all skiers in Canada are males and that they ski twice as much as women.

Somewhat different figures have been reported by Trent (15) who indicated that in 1965 there were 250,000 skiers in Canada and that the Canadian Ski Patrol System (C.S.P.S.) estimated 5,000 of the total would be injured by the end of the 1965-66 ski season. This suggested that only two per cent of all Canadian skiers would be injured. The total skiers, total injured, and percentage injured are considerably less than Ball's (14) figures. Trent added that thirty-five per cent of all skiers were over twenty-five years of age yet accounted for only fifteen per cent of the total accidents. Female skiers accounted for one-third of the skiing public and represented half of the accident total. These figures are similar to those presented by Haddon et al. (8). Eleven per cent of males and thirty per cent of females practiced the snow plow technique yet they accounted for one-half of the total accidents (15).

McIntyre (16) indicated that sixty per cent of all accidents surveyed at St. Marguerite, Quebec, occurred to persons under twenty years of age, and found that eighty-three per cent of accident victims were under thirty, a similar figure to that reported by Erskine (3) in the United States.

The Annual Medical Report of the C.S.P.S. (17) for the year 1966-67 ski year detailed percentages of injuries under a variety of headings but

failed to report a general incidence level of injuries. The report indicated that forty-six per cent of the skiing public was over twenty-five years old and had only fifteen per cent of all accidents. Skiers between the ages of fourteen and twenty-two accounted for seventy-five per cent of ski accidents. Males represented sixty per cent of all skiers and accounted for forty-eight per cent of all accidents. Fourteen per cent of males practised the snow plow technique and accounted for forty-eight per cent of all accidents to males, while forty-one percent of females snow plowed and accounted for sixty-one per cent of accidents to women. Twenty per cent of the skiing public sustained some form of ski injury at one time or another. Forty-six per cent of males and seventy-three per cent of females reported they had never taken ski lessons, yet these groups accounted for seventy-nine and seventy-seven per cent of accidents to their respective sex groups. Sixty-two per cent of male skiers and forty-seven per cent of female skiers spent in excess of twenty days per year on the ski slopes.

The Nature of Injuries

Moritz (18) noted that fifty per cent of ski accidents were sprains and strains and that fifty per cent of that total represented ankle sprains. Twenty per cent of all accidents were fractures or dislocations. Contusions accounted for a further ten per cent of the victims treated from 1939 to 1942.

Bruce et al. (19) classified 517 skiing injuries incurred by British troops in Europe in 1951. The injuries were described as major, or those requiring hospitalization, and minor, or those not requiring hospitalization. Minor injuries accounted for 417 of those injuries, all of which occurred to novices during the first three weeks of instruction. The one hundred serious accidents were related to cause only and will be discussed

elsewhere.

Sprains accounted for forty-five per cent of injuries and fractures another thirty per cent, in the survey conducted by Rigos et al. (2). Injuries to the ankles accounted for forty per cent of injuries while another twenty-five per cent occurred at the knees and fifteen per cent occurred elsewhere on the lower extremities. In total, eighty per cent of all accidents investigated occurred to the lower extremities. Kraus (20) reported similar figures using the 1958 report of the N.S.P.S. Kraus noted that over fifty per cent of all injuries were sprains, thirty per cent were fractures, and twenty per cent were lacerations. Kraus further reported that ninety-two per cent of injuries occurred to the lower extremities, a figure considerably higher than that reported by Rigos et al. (2).

Arnott (6) found that in excess of eighty-five per cent of the total injuries occurred to the lower extremities. Fractures accounted for thirty-nine per cent of injuries, sprains fifty-one per cent, and lacerations fourteen per cent. Leg fractures accounted for about fifty-five per cent of fractures, while ankle fractures accounted for another forty per cent. Ankle sprains accounted for fifty-five per cent of all sprains and knee sprains accounted for another forty-two per cent. Fifty per cent of the total lacerations occurred to the lower extremities. The study revealed that the injuries sustained occurred equally to the left and right sides of the body. Arnott noted that the thirteen to seventeen age group accounted for more than half of the sprains and about one-third of the fractures. It should be stressed, however, that there was no information given to indicate what percentage of the total ski population was made up of that age group.

Erskine (3) reported that eighty per cent of ski injuries occurred to the lower extremities, similar to the figure reported by Rigos et al. (2).

Erskine noted ankle injuries represented forty-four per cent of the total while knee injuries accounted for nineteen per cent and other injuries to the legs, twenty per cent, figures again similar to those of Rigos et al. (2).

Moritz (4) studied a five hundred day period during which 2,578 skiers were injured at Sun Valley, Idaho. A distribution of injuries as tabulated is found in Table III (4). It can be seen that sprains and fractures to the leg accounted for seventy-three per cent of all injuries.

TABLE III

Ski Injuries

Sprains		1,496	58 per cent
Ankle	783		
Knee	601		
Fractures of Leg		378	15 per cent
Others		704	27 per cent
		2,578	

Ball (14) recorded slightly lower figures than those recorded by Erskine (3) and Rigos et al. (2). Ball's Canadian study revealed that sixty-five per cent of total injuries occurred to the legs, of which thirty-nine per cent were leg sprains and strains, and leg fractures and lacerations accounted for seventeen per cent each.

Earle et al. (7) published very similar results to those expressed by Erskine (3) and Rigos et al. (2). The authors found that forty-five per cent of recorded injuries were sprains and strains, twenty-two per cent were fractures, sixteen per cent were contusions and haematomas, and nine

per cent were lacerations.

Leidholt (21) reported that forty per cent of all injuries occurred at the ankle. Of the accidents to the ankle Leidholt stated "there are two sprains to every fracture of the ankle" (21).

McIntyre's Canadian survey (16) disclosed that eighty-eight per cent of the accidents recorded occurred to the lower extremities, a figure comparable to that expressed by Haddon et al. (22). Haddon et al. reported that eighty-eight per cent of sprains and eighty-nine per cent of fractures involved the lower extremities. Sprains to the ankle accounted for forty per cent of all sprains, while knee sprains accounted for thirty-nine per cent. Lacerations accounted for eleven per cent of the total accident figure. In relating accidents to turn groups and sex, the authors noted that seventy-seven per cent of ankle sprains of the intermediate-expert ski groups occurred to men, and sixty-five per cent of ankle sprains in the beginner group occurred to women. Nearly forty per cent of the knee sprains in each of the intermediate-expert, novice, and beginner groups occurred to men, with the women of each group accounting for remaining percentage. Haddon et al. noted twenty-five per cent of knee sprains were associated with a sprain or fracture of the ankle.

Harwood (13) has tabulated the number and percentage of skiing accidents treated from 1960 to 1964 in a twenty-five mile radius of Syracuse, New York. The figures are presented in Table IV (13). Harwood noted that sixty-four per cent of the injured skiers sustained injury from torsional strain.

The C.S.P.S. has indicated in the 1966-67 accident report that thirty-two per cent of the males and thirty per cent of the females injured suffered fractures, thirty-six per cent of males and forty-seven per cent of females suffered sprains, and twenty-one per cent of males and twenty-eight

per cent of females suffered lacerations (17). Injuries to the lower extremities accounted for seventy-one per cent of all injuries to males and eighty-one per cent of the injuries to females, figures which are similar to those reported by Trent (15). Head injuries accounted for ten per cent of injuries to males and seven per cent to females. In the final analysis the C.S.P.S. report indicated that one in twenty skiers had broken a leg at one time or another.

TABLE IV

Ski Injuries at Syracuse, New York

1960 to 1964

Type of Injury	Number	Percentage
Fracture of tibia shaft or shaft of tibia and fibula	105	16
Fracture of foot and ankle	55	8
Other fractures	30	5
Shoulder dislocations	9	2
Knee sprains	142	22
Ankle sprains	115	18
Other sprains and contusions	54	8
Lacerations	140	21
Total	650	100

Causes of Ski Injuries

The immediate cause of most ski injuries is torsion (twisting) resulting from a fall. Such a cause is reflected in the large proportion of accidents occurring to the limbs. Early studies indicated that torsion

was the major cause of injuries to skiers (1,18,19). Studies conducted in the last fifteen years have gone beyond the immediate cause and turned to the environment to attempt to establish reasons leading skiers into falls. In some cases the psychological nature of the skier has been viewed as, perhaps, a related cause of injury.

Bruce et al. (19) classified the skiers surveyed into groups depending upon their skiing experience. Group one was comprised of skiers with more than one year of experience, group two included skiers whose experience exceeded one month, and group three included those with less than one month's experience. The groups were classified with particular reference to: (a) type of snow, (b) type of fall, (c) presence or absence of hazard, and (d) severity of injury. The findings are summarized in Table V. There were one hundred injuries in total, nineteen of which occurred in group one and the remainder in the other two groups. In summing up, the authors pointed out that if experienced skiers had an accident it was more likely to be serious and that hazards were associated with more serious injuries in experienced skiers (19).

Bruce et al. (19) and Williams (23) indicated that two common causes of injury in the inexpert skier were crossed skis and skiing from packed slopes into deeper snow. Rigos et al. (2) concluded that because most injuries occurred later in the ski day, fatigue and changing light and slope conditions accounted for many accidents. The investigators noted that most inexperienced skiers were injured due to lack of skill and judgment, while experienced skiers were injured due to lack of judgment only. Table VI depicts the causes of injury established (2).

Kraus (20) agreed with Rigos et al. (2) that lack of skill was a main cause of injury and added that lack of proper physical condition was another major cause. Kraus stated that "speed, snow conditions, visibil-

ity, and trail conditions are hazards only when they are not properly recognized and managed" (20).

TABLE V

Ski Accidents

Group One

(a) Type of snow: widely varied, hence not significant.

(b) Type of fall: one-half were twists, one half were straight falls.

(c) Hazard: thirteen of nineteen listed definite hazard such as a rock, stump, or a sudden dip.

(d) Type of injury: nine of nineteen suffered serious injury.

(e) Related to (d): six of thirteen experienced skiers suffered injury due to positive hazard.

Groups Two and Three

(a) Type of snow: about seventy per cent of novices attributed their fall to skiing off pista (a prepared run) into soft snow.

(b) Type of fall: about seventy per cent of novices were hurt in twisting falls, the rest in straight falls.

(c) Hazard: only ten of eighty-one listed a hazard as the cause of injury other than skiing from pista to soft snow.

(d) Type of injury: only two of eighty-one were of a more serious nature.

Arnott (6) noted that about seventy-five per cent of all novice casualties were injured on moderately steep terrain. About eighty-three per cent of intermediate skiers were injured on slopes of a similar designation, while fifty-seven per cent of expert skiers suffered injuries skiing moderate terrain. Forty per cent of the expert skiers injured sustained injury on steep terrain. Arnott estimated that two-thirds of all skiers used "safety bindings" but that group accounted for only forty-four per

cent of the recorded accidents (6). The accidents recorded in Arnott's study occurred at almost a steady rate throughout the day and there was no apparent increase in the frequency of accidents in the very early and latter stages of the skiing day. This suggested that lack of warm-up in the early morning, or fatigue in the late afternoon did not account for an increase in accidents.

TABLE VI

Causes of Ski Injuries

Speed beyond ability	28 per cent
Terrain beyond ability	23 per cent
Obstacles	14 per cent
Tow or lift area	11 per cent
Fatigue	8 per cent
All others	16 per cent

Loss of control was given as the cause of thirty-eight per cent of the accidents reported, while faulty equipment was the cause of thirteen per cent of the accidents. Caught tips and sitz marks (holes in the slope surface) accounted for seventeen and seven per cent of accidents, respectively.

Erskine (3) felt that fatigue was a major cause of accidents as some fifty per cent of accidents occurred after two in the afternoon. Erskine suggested that a psychological factor, causing tension at the confrontation of a dangerous situation, might be a major cause of accidents.

With specific reference to re-injury, Kraus (24) indicated that weakness and stiffness and hence lack of conditioning was a major cause of re-injury. Exercise was recommended as a good preventive measure for

those skiing on once injured limbs.

Hendryson (5) noted that forty-three per cent of injuries occurred on packed slopes and forty-one per cent in soft snow. Since soft snow slopes are less common than packed slopes, the accident rate in soft snow appears considerably higher than the packed slope rate. Hendryson revealed that thirty per cent of accidents occurred to skiers during their first hour on the slope and twenty-one per cent occurred after two o'clock. This suggested that lack of warm-up and fatigue contributed to accidents. Seventy to eighty per cent of accident victims disclosed that their accidents occurred because they lost control. Thirty per cent of victims stated they hit something and ten per cent sustained injuries on or at the tow or lift areas.

Moritz (4) felt that moguls or snow mounds were a cause of accidents due to their increasing presence on the hills. However, Moritz pointed out that using slope conditions as an excuse for an accident only served to reveal an inability of the skiers to handle the slope conditions as they existed. Collision was a major cause of accidents and in almost all cases was blamed on poor skier judgment and a general inability of the skier to control his descent. Lacerations were attributed to flailing skis and offset metal edges. Improperly adjusted and maintained ski binding equipment was given as the cause for premature binding release or complete failure to release.

McIntyre (16) listed four basic causes of accidents: (a) loss of control, resulting from improper conditioning, inexperience and faulty technique, fatigue, or excessive speed; (b) dangerous skiing conditions, including ruts, moguls, obstacles, and changes in the condition of the slope; (c) weather conditions, such as extreme cold or conditions resulting

in poor visibility; and (d) faulty or improperly adjusted equipment.

Howorth (25) felt that the "schussboomer" and show-off skiers were a main cause of injury to less experienced skiers. This reasoning stemmed from the results of questionnaires completed by injured skiers which indicated, in many cases, that attempted avoidance of such skiers had resulted in falls causing injury. Howorth suggested that false ski reports on slope conditions might lull skiers into performing beyond what they normally would have done had they known the true conditions. Howorth also felt that rented and borrowed equipment was a cause of accidents, pointing out that in a great many instances the equipment was improperly fitted and adjusted. This view was shared by Haddon et al. (8).

Percentage breakdowns on various causes of accidents were tabulated in C.S.P.S. annual accident report for the 1966-67 season (17). Causes of accidents are shown in Table VII. Forty per cent of males and forty-two per cent of females, who listed snow conditions as the cause of accident, blamed packed slope conditions for their accidents. Another twenty-three per cent of males and twenty-four per cent of females listed powder snow as the cause. One-half of those people blaming faulty equipment for their accident stated that their release bindings failed to release. Sixty per cent of males and seventy per cent of females suffering injury were not in condition.

Summary

The incidence of injury varied greatly from ski area to ski area but in general it approached a level of one per cent, or ten injuries for every one thousand skiers per day. Novices accounted for a large portion of injuries, the majority of which were of a less serious nature. Experts accounted for few injuries; however, when injured, experts usually sustained

injuries of a more serious nature. Women appeared to have a slightly higher injury rate than men. Age would appear to affect injury levels as older persons suffered fewer injuries while fourteen to twenty-two year olds had a much higher accident rate.

TABLE VII

Accident Causes

Cause	Percentage of Males Injured	Percentage of Females Injured
Lift	5	6
Racing	3	2
Collision	5	6
Faulty Equipment	8	6
Visibility	2	2
Snow Conditions	24	25
Carelessness	16	16
Moguls	13	11
Other	21	24

The majority of injuries were sprains and strains while fractures occurred about one-half as often. Between eighty and ninety per cent of all accidents reported occurred to the lower extremities. Lacerations were quite common, notably on the legs and to the head region. Offset steel edges and slippery slopes have generally been blamed for lacerations. Multiple injuries such as both knee and ankle sprains or a knee sprain and a leg fracture are not uncommon.

Apart from the fact that most injuries resulted from a fall, a variety of other factors were present to initiate the fall. Often the causes

related to particular conditions as they existed at the resorts or ski areas individually. Common causes included: improperly adjusted and fitted equipment, weather conditions, slope or hill conditions, fatigue, collisions, lift or tow areas, and skier inability or improper technique.

While the nature of injuries was largely similar in most studies, incidence of injury and causes of injuries were largely indigenous to the ski areas in which the surveys were compiled.

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CHAPTER III

METHODS AND PROCEDURES

Methods

To investigate the incidence, nature and cause of ski accidents at Marmot Basin, the survey technique was chosen.

Because the existing accident report form of the Canadian Ski Patrol System was judged inadequate, a report form was devised specifically for the study. A suitable design was assembled on the basis of information gathered from past studies and under consultation with knowledgeable people. Appendix A presents the adopted accident report form. Forms were numbered sequentially for control purposes.

Since the report form could not be completed exclusively by the investigator, the cooperation of the Canadian Ski Patrol System, Edmonton Zone, which operated voluntarily at Marmot Basin on weekends and holidays, was sought concerning completion of the accident reports.

Prior to the 1968-69 ski season, the Canadian Ski Patrol System, Edmonton Zone, and the operators of Marmot Basin Ski Lifts Limited, introduced the accident report form to the volunteer and professional ski patrol of the Marmot Basin area respectively. In training sessions all patrollers of the area were instructed in the use of the form. The responsibility for ensuring that the reports were completed was given to the supervisor of the professional patrol and the Marmot Basin patrol leader of the Canadian Ski Patrol and his two assistant patrol leaders. While the writer served as a volunteer member of the Canadian Ski Patrol in the area, he did not directly supervise the completion of each form.

Procedures

The accident reports were completed as the victims were being readied

for their removal from the ski area. In instances where speed was of the essence, the report form was completed in the ambulance en route to the Seton Hospital in Jasper, Alberta. Only twice during the entire season was it necessary to make special trips to the hospital at the end of the ski day to complete reports on treated victims.

At periodic intervals the investigator removed completed forms from the hill and retained them for IBM key punching and analysis.

Early in the season, it became apparent that the nature of the accidents needed to be validated. Under discussion with the Jasper Medical Group, a team of three medical doctors who practice at the Seton Hospital in Jasper, the director of the Group, Dr. J. P. Betkowski, agreed to verify for the investigator the nature of the injuries to those persons appearing on the ski accident forms. In this manner the nature of the injuries sustained by victims treated at the Seton Hospital after their removal from the ski hill were verified.

Since not all victims were treated by the Jasper Medical Group, validation of the injuries sustained by the additional victims was carried out by the investigator through personal communication where it was deemed desirable.

After validation of all reports, the forms were photo-copied and the copies sent to the resort operators for legal purposes, while the originals were retained by the investigator for analysis.

The transfer of data from the reports to IBM eighty column hollerith cards began at the end of the ski season. The cards were subsequently run through the computer under conditions designed to yield accumulations and causitive data.

CHAPTER IV

RESULTS AND DISCUSSION

Incidence

During the 1968-69 skiing season there were 56,693 skiers at Marmot Basin. Of this total 186 were treated for injury by the ski patrol operating in the area. The incidence of ski injury thus observed was 3.28 persons per thousand skiers on any ski day, or 0.328 per cent. The accident rate for weekend and holiday skiing was 3.58 persons per thousand skiers per day.

A greater occurrence of injury was observed in the months of November and December when 4.10 and 5.06 persons per one thousand per day were injured respectively. Other monthly rates per one thousand ski-man days were: January 2.92, February 2.80, March 2.96, and April 3.34. Table VIII provides a summary of daily, monthly and seasonal incidences.

Sex

Fifty-two per cent of the injuries sustained during the 1968-69 ski season at Marmot Basin were to men. Men suffered twice as many head injuries and lower leg injuries as women, while women sustained twice as many ankle injuries and one and one-half times as many knee injuries as men.

Men sustained three and one-half times as many lacerations and one and one-half times the number of fractures women suffered. Women suffered three times the number of sprains men sustained. Muscular strains and other injuries were shared equally by both sexes or were too few to warrant adequate comparisons.

Women attributed their injury to loss of control thirty-three per cent of the time, and an additional fourteen per cent occurred travelling from

TABLE VIII

MARMOT BASIN SKI POPULATION AND INCIDENCE OF INJURY 1968 - 1969

	NOVEMBER			DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL		
DAY	Ski Pop.	In-juries	00.00%	Ski Pop.	In-juries	00.00%	Ski Pop.	In-juries	00.00%	Ski Pop.	In-juries	00.00%	Ski Pop.	In-juries	00.00%	Ski Pop.	In-juries	00.00%
1				583	6	1.03	486	1	0.21	273	---	---	1439	3	0.21	235	---	---
2				105	---	---	807	3	0.37	478	1	0.21	1168	5	0.43	250	---	---
3				75	1	1.33	1083	1	0.09	71	---	---	259	1	0.39	323	1	0.31
4				73	1	1.37	1135	2	0.18	92	---	---	258	---	---	1209	5	0.41
5				90	1	1.11	908	4	0.44	123	---	---	432	---	---	1322	7	0.53
6				99	---	---	192	---	---	144	---	---	567	---	---	1023	1	0.10
7				579	2	0.35	117	---	---	79	1	1.27	868	5	0.58	1024	4	0.40
8				726	5	0.69	60	---	---	1066	3	0.28	1296	6	0.46	1067	3	0.28
9				75	---	---	32	---	---	1147	1	0.09	1279	4	0.31	1094	3	0.27
10				86	---	---		CLOSED		117	---	---	245	2	0.82	873	2	0.23
11				38	---	---		CLOSED		81	---	---	215	---	---	714	5	0.70
12				52	---	---	8	---	---	90	---	---	216	1	0.46	607	2	0.33
13				71	---	---	16	---	---	76	---	---	219	2	0.91	517	1	0.19
14				440	3	0.68	24	---	---	118	---	---	210	---	---	137	---	---
15				577	5	0.87	35	---	---	892	5	0.56	1120	3	0.27	110	---	---
16				81	1	1.23	33	---	---	1035	5	0.48	1251	2	0.16	89	---	---
17				64	2	3.13	28	---	---	221	2	0.90	267	---	---	106	---	---
18				60	---	---	335	3	0.90	184	1	0.54	283	2	0.71	79	---	---
19				78	---	---	221	---	---	282	---	---	300	1	0.33	312	---	---
20				136	1	0.74	21	---	---	612	4	0.65	280	1	0.36	352	3	0.85
21				511	3	0.59	17	---	---	716	1	0.14	290	---	---	CLOSED		
22				607	1	0.16	6	---	---	1276	4	0.31	996	3	0.30	CLOSED		
23	89	---	---	287	---	---	12	---	---	1205	4	0.33	1201	3	0.25	CLOSED		
24	176	1	0.57	308	---	---	30	---	---	152	1	0.66	372	1	0.27	CLOSED		
25	28	---	---	271	1	0.37	256	1	0.39	140	---	---	309	1	0.32	CLOSED		
26	24	---	---	315	---	---	90	---	---	167	---	---	272	---	---	257	1	0.39
27	28	1	3.57	231	---	---	12	---	---	745	1	0.13	255	---	---	294	2	0.68
28	28	---	---	CLOSED			28	---	---	939	1	0.11	251	1	0.40			
29	56	1	1.78	CLOSED			60	1	1.66				713	4	0.56			
30	544	1	0.18	181	3	1.66	22	---	---				886	2	0.23			
31				315	---	---	83	2	2.41				217	---	---			
Sub Totals	973	4	0.41	7114	36	0.51	6157	18	0.29	12521	35	0.28	17934	53	0.30	11994	40	0.33

Grand Totals 56,693 SKI POPULATION, 186 INJURIES, PERCENT INJURIES 00.328%

packed to loose snow. Male percentages for the same causes were twenty-nine, thirteen, and eighteen, respectively.

Ten per cent of all males injured were associated with the beginning snow plow turn group, ten per cent with the novice snow plow group, nine per cent with the novice stem christie group, sixteen per cent with the intermediate stem christie turn group, and thirty-four per cent with the intermediate parallel group. Female percentages tended to be in reverse, as thirty-six per cent of women injured were associated with the beginning snow plow group, thirteen per cent the novice snow plow group, eleven per cent the novice stem christie group, thirteen per cent the intermediate stem christie group, and sixteen per cent the intermediate parallel group.

Thirty per cent of women hurt were on beginner slopes, which was three times the percentage of men. Men sustained fifty-four per cent of their injuries on the intermediate slopes, which was twice the percentage of women. Thirty-eight per cent of women were hurt on the novice slopes while only twenty-seven per cent of men were injured on the same slopes.

Age

Table IX reflects the number of people in each age group that sustained ski injuries. Fifty-nine per cent of all injuries were to the twenty and under age group. The same age group accounted for sixty-two per cent of sprains and sixty per cent of fractures.

Both injuries in the under six category were lower leg fractures. Of the total injured in the six to nine age group, thirty-one per cent sprained ankles, twenty-three per cent strained knee muscles, fifteen per cent sprained knees, and fifteen per cent broke lower legs. Fifty-nine per cent of those injured in the ten to twelve age group suffered lower leg fractures. Twenty-seven per cent of thirteen and fourteen year olds broke

their lower leg, while eighteen per cent sprained ankles. Seventeen per cent of seventeen and eighteen year olds sprained knees while twenty-nine per cent of the nineteen and twenty age group sprained ankles. Sprained knees and fractured lower legs each accounted for one-quarter of the injuries to the twenty-one and twenty-two year old skiers. Thirty-eight per cent of the thirty-six to forty age group fractured lower legs.

TABLE IX

Incidence of Ski Injuries by Age

Age Group	Percentage of Total Injuries
Under 6	1
6 - 9	7
10 - 12	9
13 - 14	8
15 - 16	11
17 - 18	12
19 - 20	11
21 - 22	7
23 - 24	5
25 - 26	8
27 - 28	5
29 - 60	16

Height and Weight

These factors failed to reveal any significant trends except when related to skis and poles. As the nature of the association tended to take on more meaning in the discussion reserved for these two categories, the trends are discussed elsewhere in this chapter.

Time of Accident

Seventy-two per cent of all injuries occurred after twelve o'clock noon. Seventy-six per cent of all injuries to the lower extremities occurred after twelve o'clock. Eighty-one per cent of muscular strains,

seventy-seven per cent of fractures occurred after twelve o'clock. Forty-five per cent of abrasions and forty-one per cent of lacerations occurred prior to twelve o'clock.

TABLE X

Incidence of Injury by Time

Time Period	Percentage of Total Injuries
9 - 10 a.m.	5
10 - 11 a.m.	14
11 - 12 noon	9
12 - 1 p.m.	18
1 - 2 p.m.	17
2 - 3 p.m.	18
3 - 4 p.m.	18
After 4 p.m.	1

Body Region Injured

The 186 ski accidents resulted in injuries to 202 body sites. The lower extremities were sites of injury 140 times, or sixty-nine per cent of the total number. Table XI provides a breakdown of injuries by body region. No injuries to the teeth or groin region were recorded. The side of the body injured was indicated on those injuries which required follow-up. Of a total of 137 follow-up studies, sixty-nine injuries occurred to the right side of the body and sixty-eight to the left. Left lower extremities were injured fifty-seven times and right legs fifty-five times.

Sixty-five per cent of lower leg injuries were sustained by ten to twenty year old skiers. Forty-seven per cent of ankle injuries were sustained by the fifteen to twenty age group. Thirty-six per cent of head injuries occurred to intermediate parallel turn group skiers, and twelve

per cent to each of the categories of expert parallel skiers and racers. Thirty-three per cent of arm injuries were sustained by intermediate parallel skiers, while seventeen per cent occurred to each of beginning snow plow and novice snow plow skiers. Forty and twenty per cent of knee injuries were sustained by the beginning snow plow and intermediate stem christie groups respectively. Twenty-eight per cent of lower leg injuries were sustained by intermediate parallel skiers and twenty per cent by beginning snow plow skiers. Beginning snow plow skiers also accounted for twenty-eight per cent of the ankle injuries, two per cent more than ankle injuries to intermediate parallel turn group skiers.

TABLE XI

Incidence of Injury Related to Body Region

Body Region Injured	Percentage of Total Injuries
Head and Face	13
Neck	1
Shoulder	5
Arm and Hand	9
Chest and Abdomen	1
Back	1
Buttocks	0.5
Thigh (Upper Leg)	2
Knee	20
Lower Leg	25
Ankle	21
Foot	1
Other	0.5

Type of Injury

Table XII depicts the percentages of the various types of injuries during the 1968-69 skiing season. The 186 injured suffered 210 different injuries indicating that thirteen per cent had multiple injuries, one of

a serious nature and usually one of lesser consequence. Four persons sustained multiple injuries and in these four cases more than one injury was regarded as serious. The injury categories in Table XII showing percentages greater than ten are presented below.

TABLE XII

Incidence of Injury Related to Type of Injury

Type of Injury Sustained	Percentage of Total Injuries
Abrasion	8
Contusion	6
Laceration	10
Dislocation - Separation	2
Puncture	1
Muscle Strain or Pull	12
Sprain	29
Fracture	28
Concussion	2
Frost-bite	0
Other	2

Lacerations. Sixty-four per cent of lacerations occurred at the head region. This figure is comparable to the fifty-six per cent of abrasions sustained in the same body location. Men sustained seventy-one per cent of the head lacerations. Two lacerations of a more serious nature were sustained by young men. One skier punctured his left upper eyelid with his ski pole and suffered full and rapid swelling of the eye region. A full-time professional patroller at Marmot Basin experienced an open wound on the thumb side of the left wrist. The injury was thought to be slight until the patient realized he was unable to extend his thumb. Subsequent examination revealed severance of two tendons.

Muscular Strains and Pulls. Seventy per cent of the muscular strains and pulls were in the region of the lower extremities. Forty-one per cent

of strains were associated with the knee. Sixty-seven per cent of strained or pulled knee muscles were to women. In total, women sustained fifty-six per cent of all strains and pulls. The majority of strained knees involved the internal (medial) collateral ligament. The most serious strain involved the flexors and extensors of the neck region. One female victim lost control and suffered acute flexion and extension of the neck (whiplash) and experienced temporary paralysis from the neck downward.

Sprains. Ninety-one per cent of sprains occurred to the lower extremities; half at the knee and half at the ankle. Women sustained seventy per cent of all recorded sprains. Women accounted for eighty per cent of arm sprains, seventy-four per cent of ankle sprains, and sixty-three per cent of all recorded sprains. Invariably, knee sprains involved the medial collateral ligament and were treated with cylinder casts. Three women suffered torn medial collateral ligaments; one of the three also suffered a sprain of the medial collateral ligament of the other knee and was released from hospital with two cylinder casts. In the ankle region, the medial deltoid ligament and posterior and anterior tibio-fibular ligaments were the most frequently pulled. It was not uncommon to have knee and ankle sprains accompany each other or for either to be suffered in addition to a lower leg fracture.

Fractures. Eighty-seven per cent of fractures occurred to the lower extremities - all below the knee. Twenty-two per cent of fractures occurred at the ankle while sixty-five per cent occurred in the tibia and/or fibula. Males suffered fifty-nine per cent of fractures. Women sustained fifty-seven per cent of ankle fractures while men accounted for sixty-four per cent of lower leg fractures. Two-thirds of all leg fractures occurred to the left leg. Nineteen per cent of all fractures were experienced by

the ten to twelve age group; fractures represented sixty-five per cent of skiing accidents in that age group. The tibia alone was fractured fifteen times (twenty-five per cent). There were eight transverse tibial fractures, six spiral fractures, and one chip-fracture. All but one tibial fracture involved the distal one-third of the bone. Both fibula fractures occurred to the left leg and both were transverse fractures to the distal one-quarter of the shaft. There were twenty-four tibia and fibula fractures (forty per cent). Transverse tibia-fibula fractures out-numbered spiral fractures seventeen to seven. Three comminuted fractures were recorded two of which were tibial and one which was fibular. One man sustained a long spiral fracture of the left tibia and fibula with gross separation and the distal quarter of the fibula badly comminuted. A woman suffered a transverse fracture of the distal quarter of the left tibia and fibula and a transverse fracture of the distal end of the right tibia. Twenty-two per cent of fractures occurred at the ankle. In ten instances one or more malleoli were broken. The external malleolus was fractured five times, the internal once, and both malleoli four times. One man suffered breaks in both malleoli with comminution of the internal (tibial) malleolus. The talus was fractured by three skiers. In addition to leg fractures, two colles fractures occurred, two fractures of the greater tubercles of the humerus, one fracture of the radius above the wrist, one fracture of the index finger, one rib fracture at the back, and one fracture of the upper mandible.

Of the remainder of the accidents the most serious were four dislocated shoulders, three concussions, and one dislocation of the tibia and fibula at the lower joint.

Cause of Injury

The causes of ski accidents as given by the injured are presented in

Table XIII.

Loss of control accounted for thirty-eight per cent of contusions, thirty-seven per cent of sprains, thirty-two per cent of muscle strains and pulls, and twenty-two per cent each of lacerations and fractures. Crossed skis was given as the cause of twenty-five per cent of fractures. Travel from pista (packed snow) to loose or powder snow was the apparent cause of twenty-three per cent of sprains and fourteen per cent of fractures. Loss of control accounted for forty per cent of accidents from twelve o'clock noon to one o'clock, and fifty-two per cent of accidents from three to four o'clock.

TABLE XIII

Causes of Injury Related to Incidence

Cause of Injury	Percentage of Total Injured
Lift or Tow Area	5
Racing	1
Collision	4
Faulty Equipment	8
Moguls	8
Crossed Skis	13
Sitz Mark (hole in snow)	2
Loss of Control	29
Improper Vision	2
Travel from Packed to Loose Snow	15
Other (including)	13
Hit buried stumps 5	
Caught ski edge 2	
Icy patches 1	
Hit tree 1	

Snow or Slope Conditions

Snow and slope conditions failed to reveal any significant trends when related to other factors. Ice and deep powder snow did not account

for a higher number of certain types of injuries. A discussion on snow conditions and their effects on binding release will be found elsewhere in this chapter. The relative injuries in regard to snow conditions are listed in Table XIV.

TABLE XIV

Snow or Slope Conditions as Related to Incidence

Snow or Slope Condition	Percentage of Total Injured
Deep Powder	10
Packed	58
Wet	10
Crusty	7
Icy	5
Corn Bare Falling Lightly Falling Heavily Falling Moderately	10

Light Conditions

No significant relationships were determined between light conditions and other factors. Table XV depicts those injuries occurring under various

TABLE XV

Light Conditions as Related to Incidence

Light Condition	Percentage of Total Injured
Bright	58
Light Cloud	22
Flat	10
Shadow Heavy Cloud Fog	10
Rain	0

light conditions.

Temperature

No worthwhile association could be drawn between changes in temperature readings and other injury factors.

Skill of Skier

All injured skiers were asked to assess their ability in terms of turn groups. Table XVI reflects the responses given under each of the turns presented. The first four categories, representing the least competent on skis, accounted for sixty per cent of those injured. Intermediate parallel skiers recorded forty-one per cent of lacerations and thirty-two per cent of fractures. Beginning snow plow skiers sustained thirty-five per cent of muscular strains, thirty-two per cent of sprains, and twenty per cent of fractures, while novice snow plow skiers suffered fourteen per cent of fractures and thirteen per cent of sprains.

TABLE XVI

Skill of Injured Skier Related to Incidence

Skill of Skier	Percentage of Total Injured
Beginning Snow Plow	23
Novice Snow Plow	12
Novice Stem Christie	10
Intermediate Stem Christie	15
Intermediate Parallel	25
Expert Parallel	5
Racer	6
Instructor or Ski Patroller	4

Run or Slope Where Injury Occurred

The fourteen named runs at Marmot Basin have been classified as either beginner, novice, intermediate, or expert skiing runs. Table XVII presents the number of accidents occurring on each of the types of runs.

A breakdown of injuries occurring on each slope is presented in Appendix C. The beginner slopes were given as the location of injury for twenty per cent of head injuries, twenty-eight per cent of knee injuries, twenty-two per cent of lower leg injuries, and eighteen per cent of ankle injuries. Thirty-six per cent of head injuries, thirty-three per cent of knee injuries, twenty-four per cent of lower leg injuries, and thirty five per cent of ankle injuries occurred on novice slopes. Thirty-six per cent of head injuries, sixty per cent of shoulder and sixty per cent of arm injuries, twenty-eight per cent of knee injuries, forty-eight per cent of lower leg injuries, and thirty-eight per cent of ankle injuries were sustained on intermediate slopes.

TABLE XVII

Run or Slope Where Injury Occurred Related to Incidence

Run or Slope	Percentage of Total Injured
Beginner Slopes	18
Novice Slopes	30
Intermediate Slopes	39
Expert Slopes	8
Tow Line (including departure and arrival zones)	5

An examination of Table XVIII reveals that many skiers were injured while skiing on slopes beyond their self-rated abilities. Younger skiers were the biggest offenders in this regard. In the case of the ten to twelve, thirteen and fourteen, and nineteen and twenty year old groups, from seventeen to twenty per cent of all accidents in the respective groups were incurred by beginning and novice snow plow and novice stem

christie skiers attempting to ski intermediate or expert slopes.

TABLE XVIII

Skiing Ability as Related to Incidence by Run or Slope

Skiing Ability	Percentage of Total Injuries by Slope			
	Beginner	Novice	Inter-mediate	Expert
Beginning Snow Plow	61	28	11	0
Novice Snow Plow	15	63	17	5
Novice Stem Christie	15	47	38	0
Intermediate Stem Christie	4	44	52	0
Intermediate Parallel	2	28	61	9
Expert Parallel	11	0	56	33
Racer	0	0	45	55
Instructor or Patroller	0	0	100	0

Bindings

Heel-toe release bindings were used by sixty-four per cent of injured skiers and one-half of those skiers failed to release from their bindings. Thirty-five per cent of injured skiers used cable-toe and two-thirds of those skiers failed to release from their bindings. Fifty-seven per cent of those skiers using heel-toe bindings injured the ankle, knee, or lower leg, and thirty-nine per cent sustained head, arm, or shoulder injuries. Eighty-three per cent of skiers injured using cable-toe bindings sustained ankle, knee, or lower leg injuries and eight per cent suffered from head, arm, or shoulder injuries.

Binding Adjustment

Forty per cent of the skiers injured at Marmot Basin in the 1968-69 ski season had not properly adjusted their bindings during the season.

Thirty per cent claimed they had adjusted their bindings during the season and the same percentage of victims stated they had adjusted their bindings the day of the injury. Skiers who failed to adjust their bindings sustained injury to four body regions. These skiers suffered fifty per cent of all thigh injuries, twenty-three per cent of all knee injuries, thirteen per cent of lower leg injuries, and nine per cent of ankle injuries. Students represented seventy-five per cent of the skiers who indicated they had made no binding adjustment. Forty-five per cent women and thirty-five per cent men had made no seasonal binding adjustment.

Boot Support

Seventy-eight per cent of injured skiers used high ankle boot support, while the remaining percentage used low ankle support boots. No relative associations to other factors could be inferred.

Skis and Age of Skis

Rented and borrowed skis were used by twenty per cent of the injured skiers. Metal skis were used by forty-five per cent of the injured, wooden skis by forty-two per cent, and fiberglass by thirteen per cent. Twenty-seven per cent of all skis used by injured skiers were new, twenty-seven per cent were one season old, twenty-four per cent were two seasons old, and twenty-four per cent were three seasons old or older.

Ski and Ski Pole Length

The official manual of the Canadian Ski Instructors' Alliance suggests the following ski lengths in accordance with body heights (1):

	Height in inches	Ski length in centimeters
Men	62-66	205
	66-74	210
	74-76	215
	76 and up	220

Women	58-62	190
	62-66	195
	66-70	200
Children	42-46	115
	46-50	140
	50-54	160
	54-58	180

Based on these figures twenty-five per cent of all males injured were using skis judged to be too short. The remainder were injured on skis of the correct length; no male was hurt on overly long skis. Twenty-seven per cent of women injured were using skis which were too short, while four per cent were judged to be using skis too long.

The Canadian Instructors' Alliance suggests that proper ski pole length be ascertained by having the skier invert the ski pole and grip the pole immediately below the snow basket. If the angle of the forearm to the body is at, or very near, a right angle (ninety degrees) the proper poles have been selected. This test should be performed with ski boots on. Average pole length in relation to height would be as follows (1):

Height in inches	Pole length in inches
60	40
62	42
64	44
66	46
68	48
70	50
72	52
74	54

Nineteen per cent of the men and sixteen per cent of the women injured were using poles judged excessively long.

Occupation of Injured Skiers

Slightly over fifty-nine per cent of those injured were students. Professionals accounted for nineteen per cent of those injured; office workers twelve per cent; housewives seven per cent; and laborers three

per cent. Further association with other factors failed to reveal proportions much different from those figures presented.

Lessons and Injuries

No ski lessons had been taken by thirty-eight per cent of those injured. Of that figure sixty per cent were men. Skiers who had not taken lessons accounted for fifty-three per cent of the knee injuries. Other injuries occurred in proportion to the percentage of those who had taken ski lessons.

Goggles and Sunglasses

Fifty-two per cent of injured skiers were not wearing goggles or sunglasses at the time of injury. This figure failed to relate significantly to other factors.

Ski Binding Release and Injury

Fifty-six per cent of those injured did not release from their bindings. Of that total, sixty-four per cent were women and sixty-five per cent were in the twenty and under age group. Binding release failure was associated with sixty-seven per cent of ankle injuries and sixty per cent each of shoulder, knee, and lower leg injuries. Seventy-two per cent of fractures, sixty-one per cent of sprains, and fifty-nine per cent of muscular strains were sustained by skiers whose bindings failed to release. Binding release was linked with seventy-three per cent of lacerations and seventy-two per cent of head injuries. Two-thirds of skiers injured in deep powder snow and falling snow failed to release from their bindings. Fifty per cent of the skiers injured on packed snow or ice failed to release from their bindings.

Safety Straps

Ninety-six per cent of those injured had safety straps. The four per cent who did not were young children.

Previous Skiing Injury

Twenty-three per cent of skiers injured had suffered previous ski injury. Students accounted for sixty-seven per cent and professionals eighteen per cent of those previously injured. The skiers who had suffered previous injury accounted for seventy-five per cent of shoulder dislocations and thirty per cent of head lacerations. They suffered fewer knee, lower leg, and ankle injuries than their previously uninjured counterparts.

Distribution of Accidents by Fifteen-Day Intervals

Table XIX reflects the injury rate in fifteen-day intervals.

TABLE XIX

Distribution of Accidents in Percentages Over Fifteen-Day Periods

Period	Percentage of Total Injuries
November 1 to 15	0.5
November 16 to 30	2
December 1 to 15	12
December 16 to 31	7
January 1 to 15	6
January 16 to 31	4.5
February 1 to 14	3
February 15 to 28	16
March 1 to 15	17
March 16 to 31	11
April 1 to 15	18
April 16 to 30	2

Distribution of Accidents by Skiing Days

Table XX presents a breakdown of the 186 accidents by the total

average days of skiing the victim does in a year and the number of days he had skied during the season up to the time of his injury. Fifty-two per cent of those injured had skied five days or less when they had their accidents. Sixty-seven per cent had skied under ten days. The total percentage of skiers injured who stated they skied less than ten days per season was twenty-five per cent.

TABLE XX

Average Days of Skiing Per Year Versus Total Ski Days to Date of Accident

Figures in People	Total Days Per Year						
Days to date	5 or less	6-9	10-19	20-29	30-49	50 or more	Total
1	10	7	4	7	-	2	30
2	4	7	8	4	2	-	25
3		7	4	3	2	2	18
4		5	6	-	2	2	15
5		2	5	-	1	1	9
6-9		5	9	3	7	3	27
10-19			8	9	3	4	24
20-29				4	6	6	16
30-49					7	8	15
50 or more						7	7
Total	14	33	44	30	30	35	186

Discussion

The results previously given are not presented as a proportion of the total number of skiers in the entire population. For example, while fifty-two per cent of all injuries were sustained by males, the actual male-female ratio of the entire ski population is unknown.

The higher incidence of injury in November and December suggests that inferior conditioning and lack of coordinated movement in the early

season contribute to the increased proportion of accidents. Hill and lift-line conditions early in the season are generally poorer and did show a higher cause of injury during the same period. Resort operators are encouraged to spot mark hills and close runs in poor condition in the early season because of the slower reactions of skiers at that time.

Early in the season women must emphasize joint conditioning in an effort to minimize the number of ligamentous injuries sustained to the knees and ankles.

The fact that fifty-nine per cent of all injuries occurred to the twenty and under age group and that this group was quite negligent in adequately servicing their ski-bindings points to a great need for the introduction of safety instruction in skiing in both the primary and secondary schools. Adequate attention to safety on skis easily could be covered within the confines of a school ski club if formal school instruction was judged warranted.

Increased hill surveillance and skier cautioning should be carried on by the ski patrol members from twelve o'clock noon until the end of the ski day in an effort to minimize the seventy-two per cent of accidents occurring during that period. Skiers skiing on slopes noticeably beyond their ability should be encouraged by the patrol to ski less difficult slopes and to take adequate ski lessons from certified instructors.

Ten per cent of the total injuries were directly attributable to the ski lift, tow areas, or buried rocks and stumps on the ski slopes. Resort operators are urged to provide thorough hill markings and tow line maintenance in an effort to eliminate unnecessary accidents. The fact that eight per cent of injuries occurred on moguls does not mean that moguls should be removed from the hills but rather that some poorly shaped large

moguls should be cut away and skiers with limited ability should not attempt to ski moguled areas.

It is difficult to differentiate between loss of control, crossed skis, and travel from packed to loose snow, as all three causes of injury reflect an inability to handle hill conditions or sudden changes in situation. The three factors combined totalled fifty-seven per cent of all causes of injury.

Eight per cent of those injured listed their skiing equipment as the cause of their injury. Since fifty per cent of those attributing their injury to their equipment claimed they had adjusted their bindings on the day of the injury or during the season, it is reasonably safe to conclude that the other fifty per cent, which showed a ninety-seven per cent binding release failure, lacked sufficient knowledge of the operation of their bindings.

It appears that heel-toe release bindings definitely reduce the number of lower limb injuries, but are a concomitant with the incidence of injuries to the upper extremities including the head. The choices of injury open in such circumstances would seem to indicate that a laceration or abrasion is less serious than the risk of lower leg fracture or knee or ankle sprain. Cable-toe bindings are less efficient in reducing the risks of injury and ski discharge during falls, and all skiers should be encouraged to get more efficient heel-toe releasing units. Caution is extended to pick suitable heel and toe units which compliment each other's operation (2).

People with older ski bindings did not adjust them as frequently as skiers with new equipment. Older ski equipment requires more maintenance than new equipment to retain its efficiency hence frequent adjustments should be made.

Skiers using skis judged to be too short sustained twenty-six per cent of all injuries. This indicates that short skis are not as effective in reducing accidents as previously believed (3).

The groups over twenty-six years of age suffered more injuries using ski poles judged too long. It is suggested that skiers over twenty-six should take accredited refresher ski instruction to learn the proper use of ski poles. Loss of balance due to over-poling may result in an unnecessary injury.

It is important that parents of children learning to ski provide the proper equipment related to their height and body size. Community league meetings would provide ideal opportunities for ski safety lectures and ski conditioning programs to be presented. Also the importance of knowing how new and second hand equipment can be maintained and operated for maximum safety could be stressed.

Twenty per cent of those injured were using rented or borrowed skis. Since the skiers using rented skis suffered more serious injuries (fractures, sprains, strains, and lacerations) and indicated their bindings failed to release sixty per cent of the time, distributors are urged to educate all renters in the adjustment and importance of maintenance of ski release equipment.

The fact that only half as many binding releases occurred in deep powder or falling snow as was normally experienced serves to indicate that a lighter release setting is necessary as the slopes become covered with softer snow. Skiers are advised to stop and release some of the tension on their bindings as snow builds on the slopes.

While the information was not recorded on the accident report form, several victims indicated they were skiing without corrective eye glasses

which they normally wore. All skiers must be aware of the rapid changes in hill conditions during any hill descent and therefore any aids to improve visual acuity are necessary.

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CHAPTER V

SUMMARY AND CONCLUSIONS

Purpose

The purpose of the study was to determine the incidence of injury at Marmot Basin Ski Resort and examine the nature and cause of recorded accidents so that effective and meaningful recommendations could be made which might aid in the reduction of skiing injuries in the future.

The study also served to test the feasibility of applying computerized data processing methods to the analyzing of athletic injuries.

Subjects

The persons surveyed were skiers who were injured in the Marmot Basin Ski Resort during the 1968-69 season and who required first aid and assistance from either the Marmot Basin Division of the Canadian Ski Patrols Systems' Edmonton Zone Patrol, or by professionals hired by Marmot Basin Ski Lifts Limited, the resort operators. One hundred eighty-six skiers were treated from a total skiing population of 56,693.

Procedures

An accident report form was designed specifically for the study (Appendix A). All patrollers were instructed in the use of the accident form. Casualties were removed from the ski hills by toboggan to the ski patrol hut and as the injured were readied for ambulance transportation they were questioned by assisting patrol members who completed the accident form based on the replies of the injured skiers. Where the injury was more serious the casualties were loaded in the ambulance and the form sent with the patroller assisting the driver for completion enroute to the hospital. These procedures were usually followed, however in two instances

it was necessary for the investigator to visit the victims in the hospital at the end of the ski day to have the form completed. At periodic intervals the forms were removed from the ski hill and retained for IBM key punching and data processing (Appendix B).

Results

The overall rate of injury was 3.28 persons for every one thousand skiers on any given day, or 0.328 per cent per day. The accident rate was slightly higher at the start of the season. Fifty-two per cent of all injuries were to men. Women sustained considerably more ligamentous injuries than men who suffered more lacerations and fractures.

Skiers twenty years old and younger accounted for fifty-nine per cent of the injured. Seventy-two per cent of the accidents occurred after twelve o'clock noon.

The 186 accident victims were injured at 202 body sites. The lower extremities were sites of injury sixty-nine per cent of the time. The accident sites were evenly distributed to the left and right sides of the body, however, leg fractures did occur twice as often to the left side as to the right. Sixty-five per cent of lower leg injuries were sustained by the ten to twenty year old skiers.

There were 210 injuries to the 186 casualties. Thirteen per cent of the total of 186 injured skiers suffered multiple injuries. The major injuries by percentage were: sprains twenty-nine per cent, fractures twenty-eight per cent, muscular strains and pulls twelve per cent, and lacerations ten per cent. Sixty-four per cent of lacerations were to the head region. Seventy per cent of strains and pulls were to the lower extremities. Women suffered fifty-six per cent of all strains. Sprains occurred the same number of times at both the knee and ankle, and totalled

ninety-one per cent of all sprains. Women suffered seventy-four per cent of sprained ankles, and sixty-three per cent of sprained knees.

Knee sprains usually involved the medial collateral ligament. Eighty-seven per cent of fractures involved the lower extremities; all below the knee. The ankle was fractured twenty-two per cent of the time and the lower leg bones - tibia and fibula - sixty-five per cent. Women sustained fifty-seven per cent of ankle fractures and men sixty-four per cent of lower leg fractures. Transverse fractures (boot top) occurred twice as frequently as spiral fractures.

Loss of control, crossed skis, and travel from packed to loose snow accounted for fifty-seven per cent of all listed causes of injury. Lift areas, buried stumps and rocks, and moguls were given as the cause of another eighteen per cent of all accidents.

The beginning snow plow, novice snow plow, novice stem christie, and intermediate stem christie turn groups accounted for sixty per cent of all casualties. From seventeen to twenty per cent of beginning and novice snow plow and novice stem christie skiers were injured skiing on intermediate or expert slopes.

Heel-toe bindings were used by sixty-four per cent of those injured. Sixty-three per cent of those using cable-toe bindings failed to release from their bindings while only fifty per cent of those using heel-toe bindings failed to release. Forty per cent of those injured had not adjusted their bindings during the ski season. Of the forty per cent, seventy-five per cent were students.

Twenty per cent of those injured were using rented skis. Twenty-five per cent of men and twenty-seven per cent of women were injured on skis judged to be too short for them, according to the criterion of the Canadian Ski Instructors' Alliance (1). Four per cent of women were hurt on skis

that were judged to be too long. Nineteen per cent of men and sixteen per cent of women injured used poles which were too long.

Just over fifty-nine per cent of those injured were students and nineteen per cent were professional people.

Thirty-eight per cent of the victims had never had a skiing lesson and of that total sixty per cent of the casualties were men. Skiers without lessons sustained fifty-three per cent of knee injuries while other injuries were sustained in proportion to the accident victims who had taken ski lessons.

Of those injured, fifty-six per cent did not release from their bindings. This group accounted for sixty-seven per cent of ankle injuries and sixty per cent each of shoulder, knee, and lower leg injuries. Seventy-two per cent of fractures, sixty-one per cent of sprains, and fifty-nine per cent of muscular strains were sustained by skiers who failed to release from their bindings. Binding release was associated with seventy-three per cent of lacerations and seventy-two per cent of head injuries. Twenty-three per cent of those injured indicated they had suffered previous ski injury.

Of those injured sixty-seven per cent had skied less than ten days up to the date of their accident in the 1968-69 skiing year. Only twenty-five per cent of those injured normally skied less than ten days per year.

Conclusions

Within the limitations of this study, the following conclusions have been made:

1. The injury rate of skiers at Marmot Basin Ski Resort for the 1968-69 skiing season was less than the rates reported in the majority of injury surveys presented in the review of literature.

2. The rate of injury was higher during the first two months of the skiing season.

3. Women suffered two-thirds of ligamentous injuries.

4. Three times as many women as men were hurt on the beginner slopes. Twice as many men as women were hurt on the intermediate slopes.

5. Young persons (twenty and under) suffered three-fifths of the injuries.

6. Three-quarters of the ski accidents occurred in the afternoon skiing period.

7. As the ski day progressed more skiers of low skiing ability were injured on more advanced ski slopes.

8. Nearly one-fifth of all accidents were caused by buried rocks and stumps, moguls, and the landing and departure areas of ski lifts.

9. Five-eighths of the injured skiers were hurt because they were unable to handle snow or slope conditions.

10. Heel-toe release bindings were found to be the most effective in reducing serious injuries.

11. One-tenth of injured skiers were injured because of faulty equipment. In the majority of these instances the ski equipment was three seasons old or older.

12. One-quarter of injured skiers were hurt using skis or ski poles of improper length based on the suggestions of the Canadian Ski Instructors' Alliance.

13. One-fifth of injured skiers were using rented or borrowed equipment. These skiers had a high release binding failure rate and an equally high incidence of serious injury.

14. Two-thirds of all lacerations occurred at the head, three-quarters of which were sustained upon the release of heel-toe release bindings.

15. One-eighth of the skiers injured suffered multiple injuries.

Recommendations

The results of this study revealed that a greater number of accidents could be eliminated through the co-operation of the resort operators, the skiing public, the retail ski outlets, and ski patrollers and instructors.

1. Skiers should be advised to condition themselves adequately in the pre-season in an effort to improve stamina, strengthen muscle groups, loosen joints.

2. Women should be instructed to pay particular attention to strengthening joints both in the pre-skiing period and between skiing sessions.

3. Increased hill surveillance by the area ski patrol is recommended for the period after twelve o'clock noon when the ski slopes become more crowded.

4. Ski patrollers and instructors must caution skiers of low skiing ability of the danger of skiing more advanced slopes, and advise them to enroll in accredited ski schools for instruction before attempting the more difficult runs.

5. Resort operators should provide thorough hill marking and tow line maintenance. Operators should remove poorly shaped moguls and moguls found on beginning and novice skier slopes. It is recommended that at least one full time hill marker be employed in resorts comparable in size to Marmot Basin. In the early season when hills are usually in poorer condition and skiers' reactions are slower and conditioning somewhat lacking, resort operators should not hesitate to close ski runs in poor condition.

6. Skiers are cautioned to select heel and toe release binding units which compliment each others operation.

7. Skiers are cautioned to examine ski equipment frequently and

replace it when required.

8. The Canadian Ski Technique requires that the proper skis and poles be used for maximum safety and enjoyment. Skiers are advised against using skis too short or too long and against skiing with overly long poles. Ski associations and alliances should recommend to skiers the proper ski and ski pole lengths for each body height.

9. Distributors of rented skis and people selling skis should educate all renters and new ski owners in the adjustment and importance of maintenance of ski release bindings.

10. It is recommended that skiers become knowledgeable in the operation of any ski binding they use. Ski bindings are not "safety" bindings but "release" bindings. Skiers should learn the thresholds under which they will release from their skis. After each removal of a ski from the ski boot the thresholds should be re-checked. Binding operation changes as snow builds up on the slope or under the ski boot. Skiers should be cautioned to watch for ice build-up which could disrupt the function of some ski bindings.

11. It is recommended that all ski patrolmen examine injured skiers carefully and anticipate the discovery of more than one injury, whether in close proximity or not.

12. A study of the value of protective headgear for recreational skiers using heel-toe release bindings is advised.

13. It is recommended that there be a continuous survey of this nature established on a yearly basis.

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APPENDIX A

MARMOT BASIN SKI ACCIDENT

REPORT FORM 1968-69

Marmot Basin Ski Accident Report Form 1968-69.

The Marmot Basin Ski Accident Report Form had twenty-three sections and 201 factors in addition to the small hand written section at the top of the form. The twenty-three sections were:

A. Sex
B. Age
C. Height
D. Weight
E. Time of Accident
F. Body Region Injured
G. Type of Injury
H. Cause of Injury
I. Snow or Slope Condition
J. Light Conditions
K. Temperature
L. Skill of Skier
M. Run or Slope
N. Bindings
O. Binding Adjustment
P. Boot Support
Q. Skis
R. Skis' Age
S. Ski Length
T. Pole Length
U. Occupation
V. General
W. Season Period

Each section had from two to nineteen factors. The factors for the sex section were male and female. Other factors are depicted on the accident form overleaf.

Ski Accident Report 1968-1969

MARMOT BASIN

Nº 160

Name of Skier ..... Date .....

Address ..... Patrol Number .....

City ..... Hill Number .....

Phone .....

Average Days of Skiing Per Year of Injured Skier .....

Number of Days of Skiing for Injured Skier This Year .....

CHECK OFF THE APPROPRIATE DETAIL IN THE SPACE TO THE LEFT (BEFORE) THE SELECTED ITEM.

A. Sex: ( ) 6. male ( ) 7. female

B. Age:

( ) 8. under 6	( ) 13. 17 - 18	( ) 18. 27 - 28	( ) 23. 46 - 50
( ) 9. 6 - 9	( ) 14. 19 - 20	( ) 19. 29 - 30	( ) 24. 51 - 55
( ) 10. 10 - 12	( ) 15. 21 - 22	( ) 20. 31 - 35	( ) 25. 56 - 60
( ) 11. 12 - 14	( ) 16. 23 - 24	( ) 21. 36 - 40	( ) 26. over 60
( ) 12. 15 - 16	( ) 17. 25 - 26	( ) 22. 41 - 45	

C. Height:

( ) 27. 2'6" - 2'11"	( ) 30. 4'0" - 4'5"	( ) 33. 5'6" - 5'11"
( ) 28. 3'0" - 3'5"	( ) 31. 4'6" - 4'11"	( ) 34. 6'0" - 6'5"
( ) 29. 3'6" - 3'11"	( ) 32. 5'0" - 5'5"	( ) 35. 6'6" +

D. Weight (lbs.):

( ) 36. 30 - 39	( ) 41. 80 - 89	( ) 46. 130 - 139	( ) 51. 180 - 189
( ) 37. 40 - 49	( ) 42. 90 - 99	( ) 47. 140 - 149	( ) 52. 190 - 199
( ) 38. 50 - 59	( ) 43. 100 - 109	( ) 48. 150 - 159	( ) 53. 200 - 209
( ) 39. 60 - 69	( ) 44. 110 - 119	( ) 49. 160 - 169	( ) 54. 210 +
( ) 40. 70 - 79	( ) 45. 120 - 129	( ) 50. 170 - 179	

E. Time of Accident:

( ) 55. before 9:00 a.m.	( ) 58. 11:00 - 12:00 noon	( ) 61. 2:00 - 3:00
( ) 56. 9:00 - 10:00	( ) 59. 12:00 - 1:00	( ) 62. 3:00 - 4:00
( ) 57. 10:00 - 11:00	( ) 60. 1:00 - 2:00	( ) 63. after 4:00 p.m.

F. Body Region Injured

( ) 64. teeth	( ) 69. chest and abdomen	( ) 74. knee
( ) 65. head and face	( ) 70. back	( ) 75. lower leg
( ) 66. neck	( ) 71. buttocks (rear)	( ) 76. ankle
( ) 67. shoulder	( ) 72. groin	( ) 77. foot
( ) 68. arm and hand	( ) 73. thigh (upper leg)	( ) 78. other (specify) .....

G. Type of Injury (Suspected or Confirmed):

( ) 79. abrasion — scrape, small cut	( ) 10. sprain
( ) 80. contusion — bruise	( ) 11. fracture
( ) 6. laceration — open cut	( ) 12. concussion (head)
( ) 7. dislocation — separation	( ) 13. frost-bite
( ) 8. puncture	( ) 14. other (specify) .....
( ) 9. muscle strain or pull	.....

H. Cause of Injury:

( ) 15. lift or tow area	( ) 21. stiz mark (hole in snow)
( ) 16. racing	( ) 22. loss of control
( ) 17. collision	( ) 23. improper vision
( ) 18. faulty equipment	( ) 24. travel from packed to loose snow
( ) 19. mogols	( ) 25. other (explain) .....
( ) 20. skis crossed	.....

I. Snow or Slope Condition:

( ) 26. deep powder	( ) 30. crusty	( ) 34. falling moderately
( ) 27. packed	( ) 31. icy	( ) 35. falling lightly
( ) 28. corn	( ) 32. bare	
( ) 29. wet	( ) 33. falling heavily	

J. Light Conditions: ( ) 36. bright ( ) 37. shadow ( ) 38. light overcast ( ) 39. heavy cloud ( ) 40. flat ( ) 41. rain ( ) 42. fog

K. Temperature: ( ) 43. under 10° below ( ) 44. −10° to 0° ( ) 45. 1° to 10° ( ) 46. 11° to 20° ( ) 47. 21° to 30° ( ) 48. 31° to 40° ( ) 49. 41° to 50° ( ) 50. over 50°

L. Skill of Skier: ( ) 51. beginning snow plow ( ) 52. novice snow plow ( ) 53. novice stem christie ( ) 54. intermediate stem christie ( ) 55. intermediate parallel ( ) 56. expert parallel ( ) 57. racer ( ) 58. instructor or ski patrol

M. Run or Slope: ( ) 59. beginner ( ) 60. novice ( ) 61. intermediate ( ) 62 expert

N. Bindings: ( ) 63. heel-toe release ( ) 64. cable-toe release ( ) 65. bear trap

O. Binding Adjustment: ( ) 66. prior to season ( ) 67. on day of accident ( ) 68. during season ( ) 69. not at all

P. Boot Support: ( ) 70. high ankle support ( ) 71. low ankle support

Q. Skis: ( ) 72. rented or borrowed ( ) 73. own ( ) 74. wood ( ) 75. metal ( ) 76. fibreglass (plastic)

R. Skis Age: ( ) 77. new ( ) 78. one season ( ) 79. two seasons ( ) 80. three seasons ( ) 6. over three seasons

S. Ski Length:
( ) 7. under 100 cm. (less than 39")
( ) 8. 100 to 110 cm. (39" to 43")
( ) 9. 111 to 120 cm. (44" to 47")
( ) 10. 121 to 130 cm. (48" to 51")
( ) 11. 131 to 140 cm. (52" to 55")
( ) 12. 141 to 150 cm. (56" to 59")
( ) 13. 151 to 160 cm. (60" to 62")
( ) 14. 161 to 170 cm. (63" to 67")
( ) 15. 171 to 180 cm. (68" to 70")
( ) 16. 181 to 190 cm. (71" to 74")
( ) 17. 191 to 200 cm. (75" to 78")
( ) 18. 201 to 210 cm. (79" to 82")
( ) 19. 211 to 220 cm. (83" to 86")
( ) 20. 221 cm. or over (over 86")

T. Pole Length: ( ) 21. 30" - 36" ( ) 22. 37" - 42" ( ) 23. 43" - 48" ( ) 24. 49" - 54" ( ) 25. 55" - 60" ( ) 26. 61" - 65" ( ) 27. over 65"

U. Occupation: ( ) 28. student ( ) 29. housewife ( ) 30. office ( ) 31. laborer ( ) 32. professional

V.
Has Skier Taken Lessons? ( ) 33. Yes ( ) 34. No
Was Skier Wearing Goggles? ( ) 35. Yes ( ) 36 No
Did Bindings Release? ( ) 37. Yes ( ) 38. No
Was Skier Using Safety Straps? ( ) 39. Yes ( ) 40. No
Has Skier Suffered a Ski Injury Before? ( ) 41. Yes ( ) 42. No

W. Season Period:
( ) 43. November 1 - November 15
( ) 44. November 16 - November 30
( ) 45. December 1 - December 15
( ) 46. December 16 - December 31
( ) 47. January 1 - January 15
( ) 48. January 16 - January 31
( ) 49. February 1 - February 14
( ) 50. February 15 - February 29
( ) 51. March 1 - March 15
( ) 52. March 16 - March 31
( ) 53. April 1 - April 15
( ) 54. April 16 - April 30
( ) 55. May 1 - May 15
( ) 56. May 16 - May 31

A Joint Project of

THE FACULTY OF PHYSICAL EDUCATION, UNIVERSITY OF ALBERTA

with

THE COMMITTEE FOR THE PREVENTION OF ATHLETIC INJURIES
ALBERTA SAFETY COUNCIL

APPENDIX B

COMPUTER PROGRAMS

COMPUTER PROGRAMS

Computer programs were written and debugged to accomplish data card punching, overall compilations, two section comparisons, and three section comparisons. All programs were written in Fortran IV computer language. The computer used was the IBM 360/67 installation of The University of Alberta.

Program One. This program eliminated the card punching technique described on the comment cards of program two. All factors on the accident form were numbered. These numbers were recorded in their order of appearance on a single 80 column IBM hollerith card. Generally, about 55 to 60 columns were used. All cards run behind program one were repunched according to the comment card specifications and three new cards were issued for each one read into the machine.

Program Two. The new card deck was placed behind program two which provided for overall accumulations of each section. The program then began a systematic two section comparison analysis. Each section was compared to every other section on the report form.

Program Three. This program utilized the same data deck as program two. Program three provided three section analysis where any one section and its factors was compared to any two other sections and their factors. Because of the vastness of this third program, three section comparisons were selected by the investigator.

(Programs are obtainable from the Faculty of Physical Education of The University of Alberta, Edmonton, Alberta.)

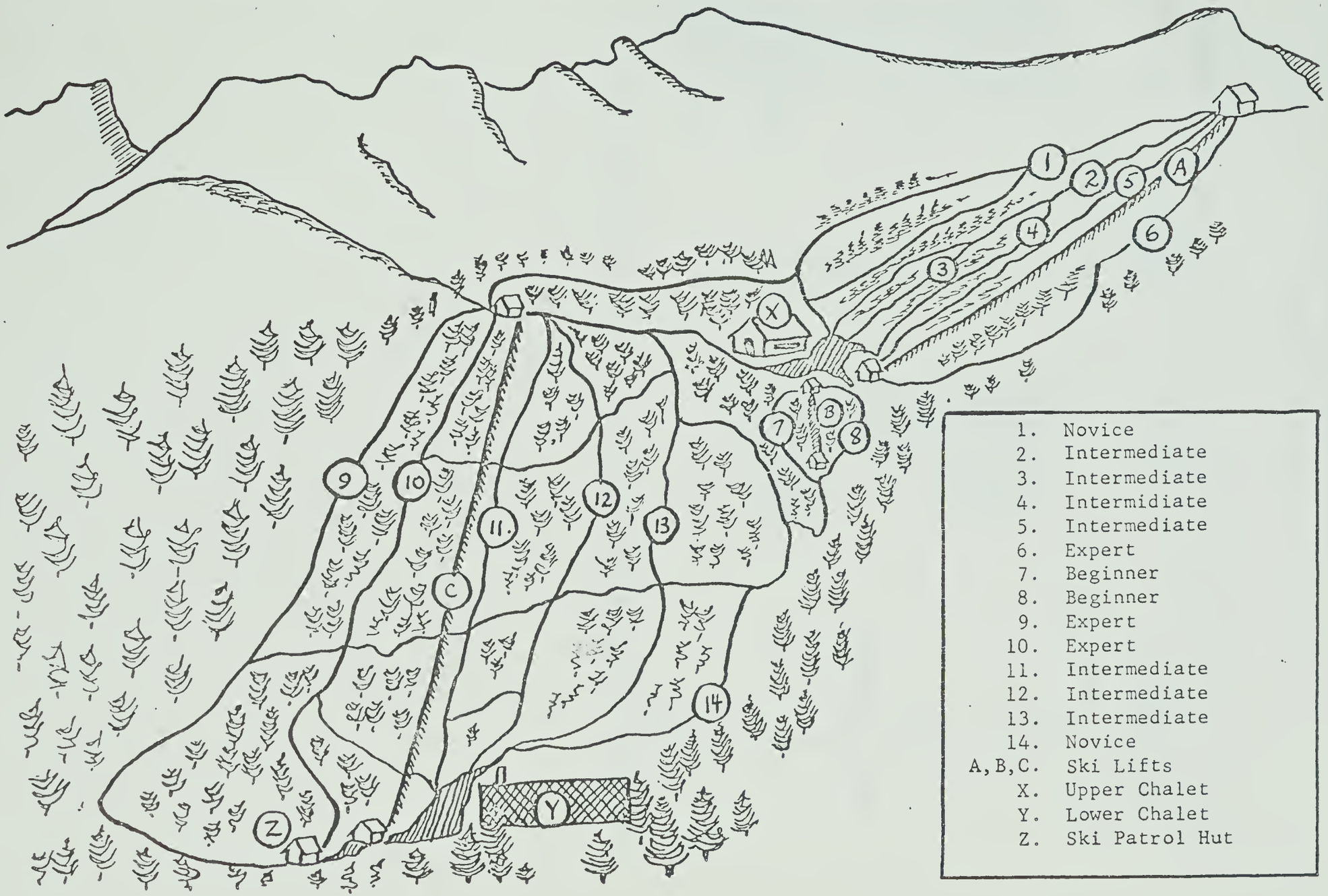
APPENDIX C

MARMOT BASIN SKI RESORT

DEPICTING SKI SLOPES OR

RUNS AND SKI ACCIDENTS

PER SLOPE



1.	Novice
2.	Intermediate
3.	Intermediate
4.	Intermidiate
5.	Intermediate
6.	Expert
7.	Beginner
8.	Beginner
9.	Expert
10.	Expert
11.	Intermediate
12.	Intermediate
13.	Intermediate
14.	Novice
A,B,C.	Ski Lifts
X.	Upper Chalet
Y.	Lower Chalet
Z.	Ski Patrol Hut

Marmot Basin Ski Slopes Related

To Incidence of Injury

Slope Name	Slope Number	Difficulty	Number of Injured Skiers
Basin Run	1	novice	44
Paradise	2	intermediate	35
Punch Bowl	3	intermediate	4
Milk Run	4	intermediate	7
Highway 16	5	intermediate	1
Show Off	6	expert	10
School House	7	beginner	24
Bunny Hop	8	beginner	1
Slash	9	expert	Closed all year
Spillway	10	expert	2
Liftline	11	intermediate	6
Dhromedary	12	intermediate	3
Tranquillizer	13	intermediate	19
Slowpoke	14	novice	19
Tow Areas			7
Other Areas			4
TOTAL			186

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